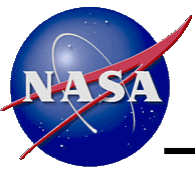




# Playing Nice Across Time & Space

Tools, Methods and Tech for Multi-Location Multi-Decadal Teams

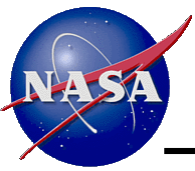
[mike.conroy@nasa.gov](mailto:mike.conroy@nasa.gov)



# A Little History

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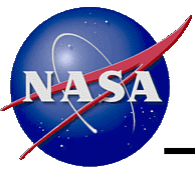
- I have been around the Modeling, Simulation, Visualization and Information Technologies for over 25 years
  - They are grand, challenging, disruptive, ever changing and incredibly powerful. They grow more so every day.
  - And, like any sharp tool, they have sharp edges.
- I would like to share some “Observations” from those years
  - As in Lessons Observed vs. Lessons Learned
  - And, I would appreciate your thoughts on things I may have missed



# How To Play Nice

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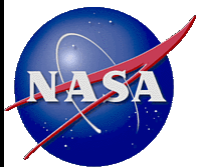
- The Game is:
  - Multi-Decade, Massive, Complex System Conception, Design, Development and Operations
  - Targeted towards a hostile and unforgiving environment
  - With a gifted, diverse and distributed group of friends
  - With the goal of getting as far off the planet as possible
- The Rules Come From:
  - Physics / Teams / Process / Science / Story
  - Time / Distance / Culture / Goals / Generations



# Some Definitions (circa 2001)

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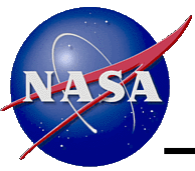
- We Model
  - We represent the **thing** we want to study
  - With as much detail as is necessary for that study
- We Simulate
  - We represent **behavior** of the thing(s) we want to study
  - With as much detail as is necessary for that study
- We Decide
  - We look at the thing(s), their behavior(s), **determine** the next step(s) and **communicate** the results of the study
  - With enough detail for that study to be used or re-used



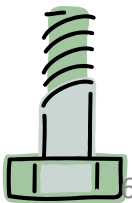
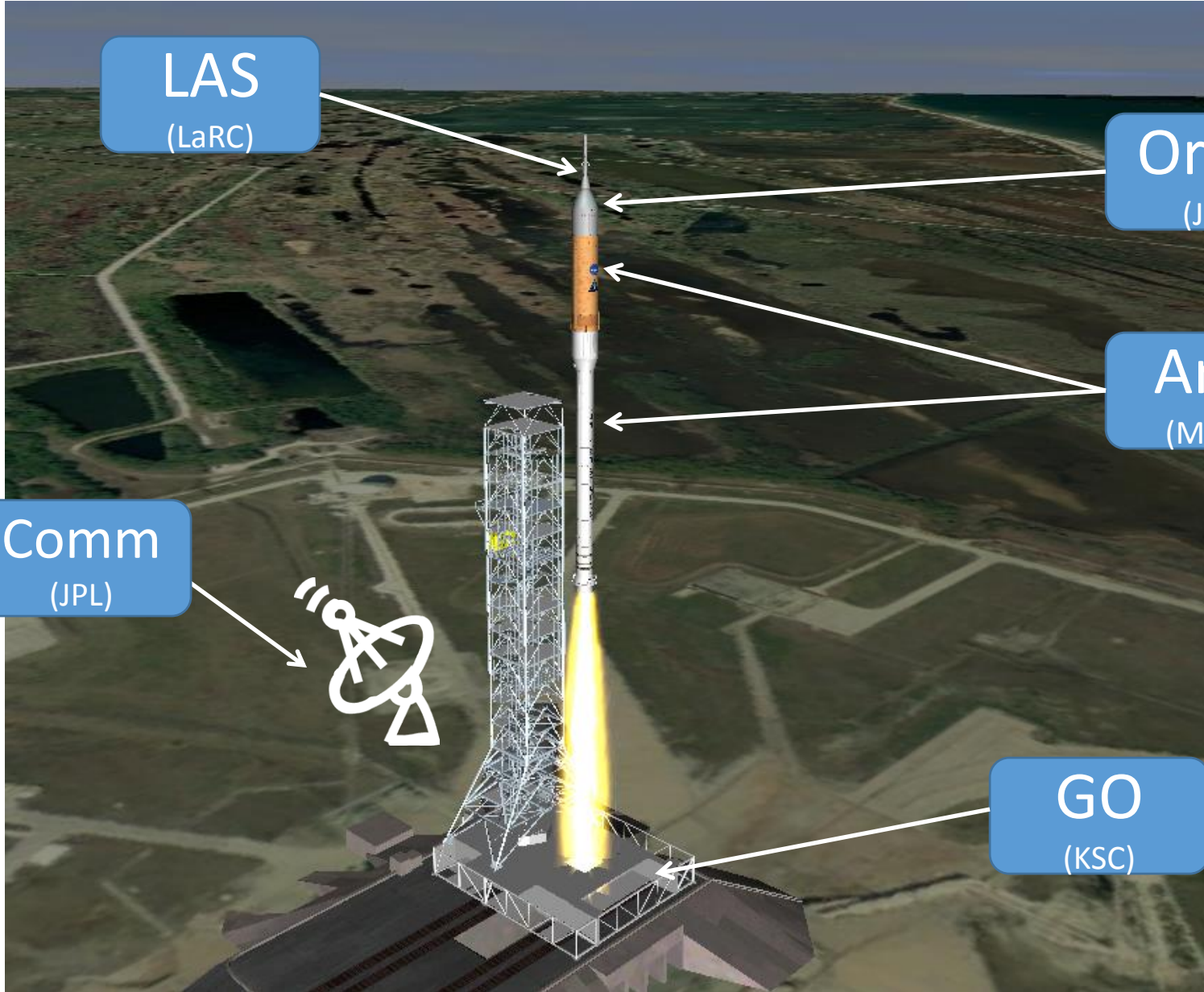
# Communications Observation

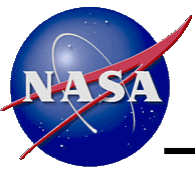
Very Large Bolts





# Ares 1 Launch Sim (HLA, Trick, 5 sites)

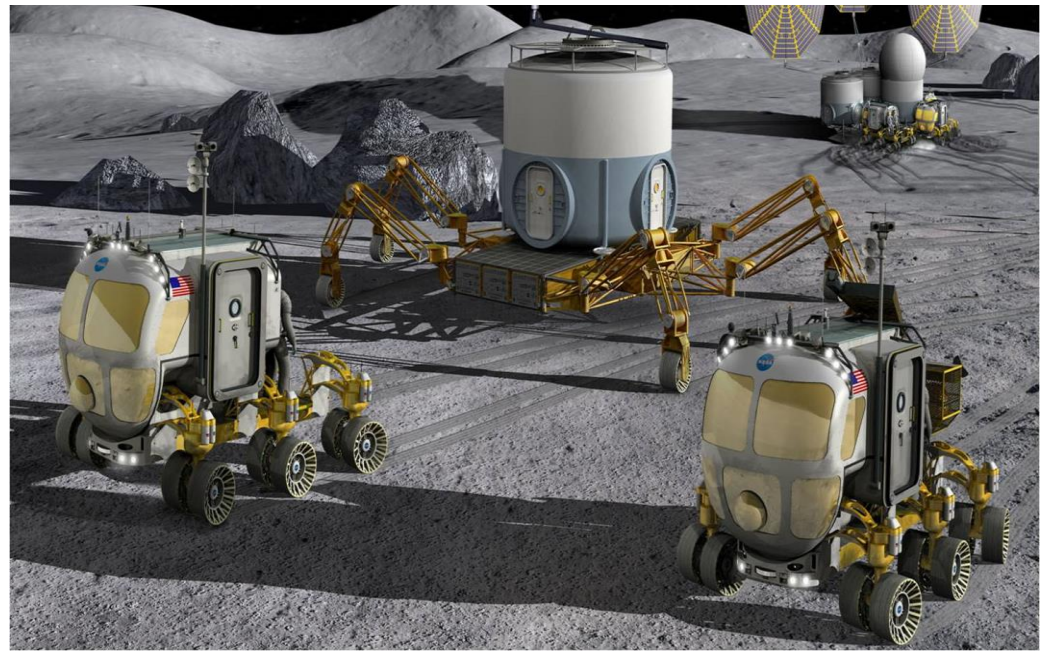




# Simulation Speeds Communication

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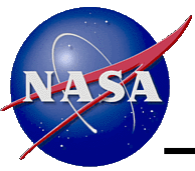
- It is non-threatening ('ish).
- Leadership is not wrong, I just need help to get the simulation right.
- Or, everyone is wrong, and we need to know now.
- Imagine 3 people vigorously discussing what is actually 3 different concepts
  - **The worst thing that can happen is that they come to an agreement and leave happy**
  - Step one is make sure everyone in the same argument



# Concurrent Design Observation

Habitat Demonstration Unit



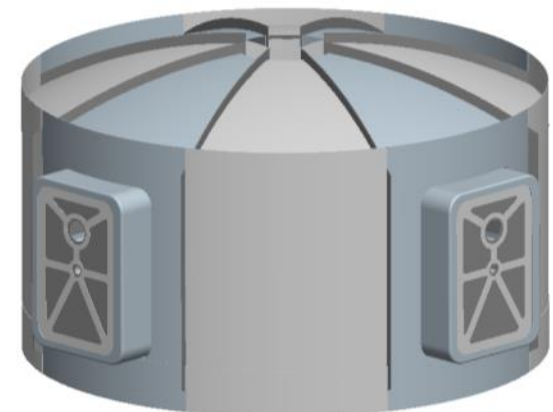


# HDU Overview

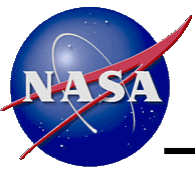
- Vision
  - Develop, integrate, test, and evaluate a Habitation prototype to better understand mission architectures, requirements and operational concepts
- Timeline
  - Project Kick-off: **June 2009**
  - Shell: October 2009 – April 2010
  - Systems Integration: **April – August 2010**
    - 10 Month Build, 4 Month Integration
  - Field Test at Desert RATS September 2010
- Participation
  - Jointly managed and built across 3 Time Zones with subsystems from 7 Centers



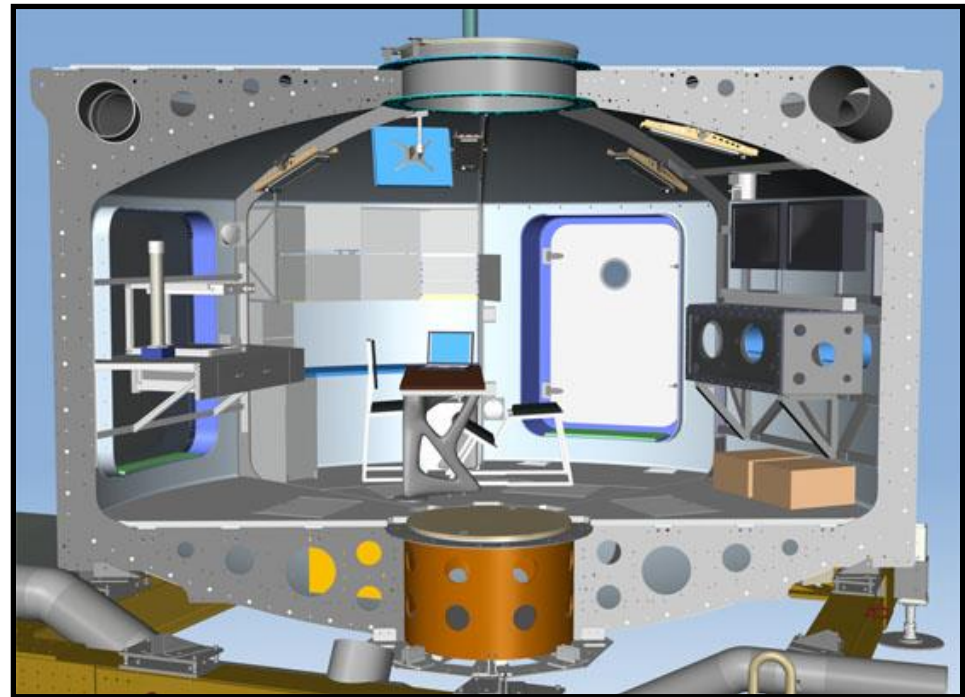
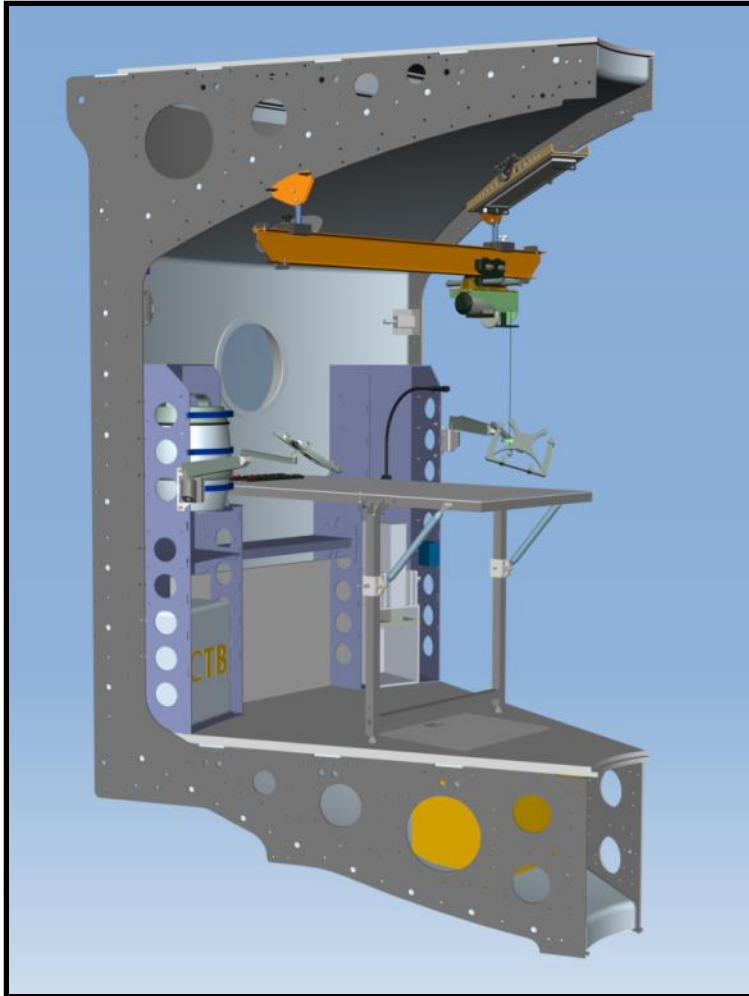
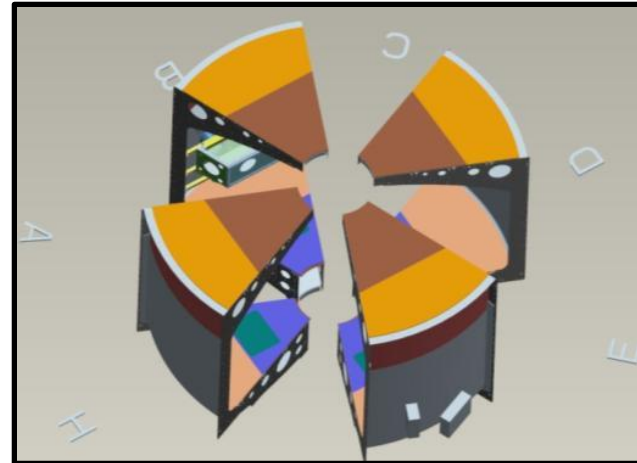
Lunar Reference Concept (PEM)

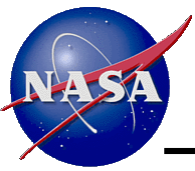


HDU Concept

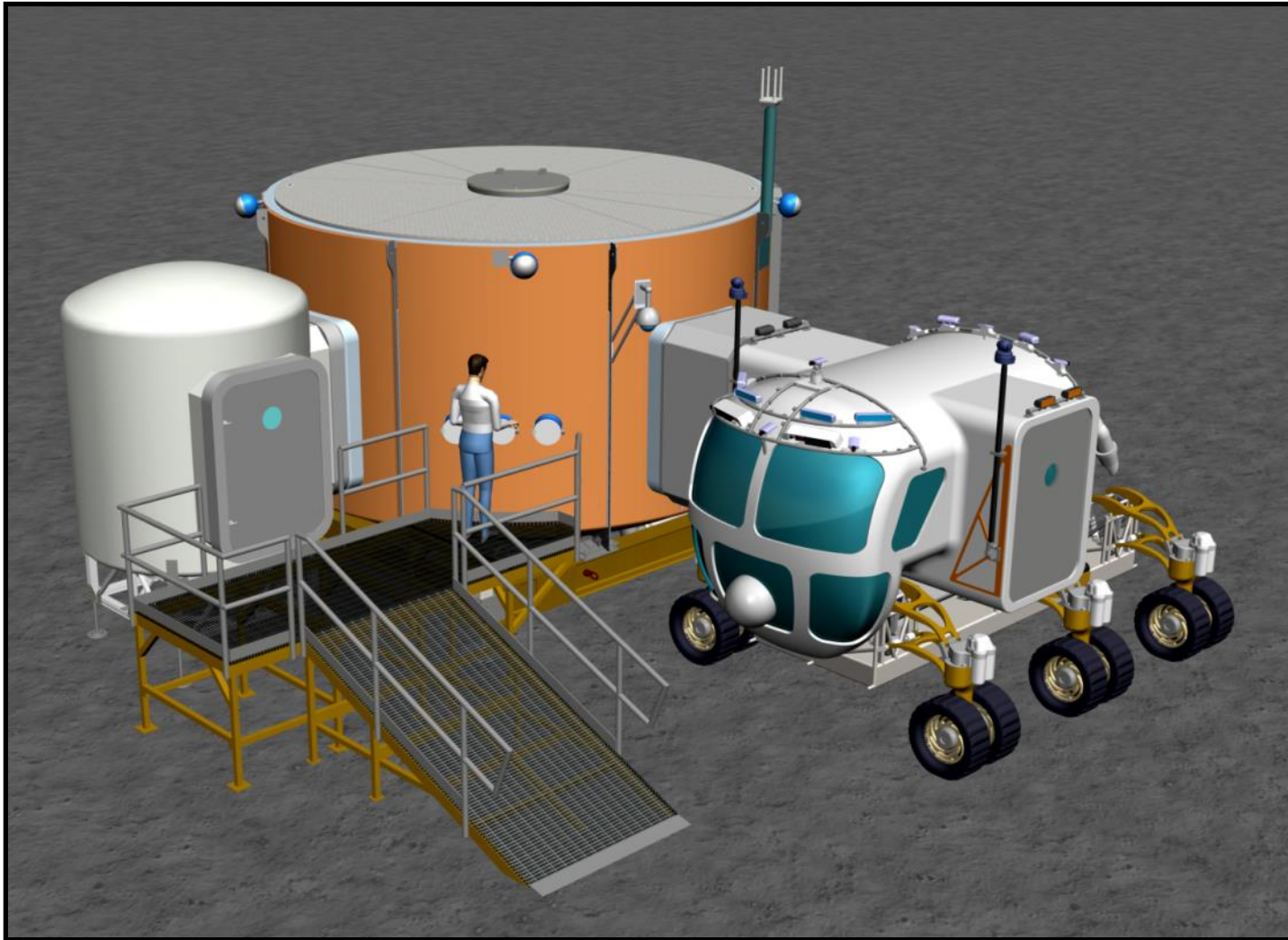


# CAD Based Integration - Interior

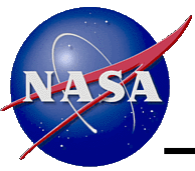




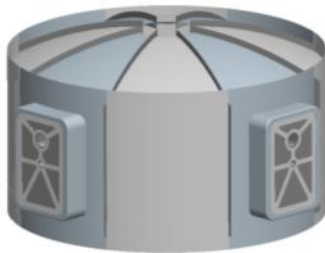
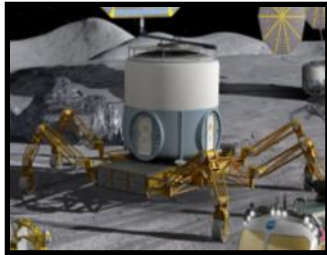
# CAD Based Integration - Exterior

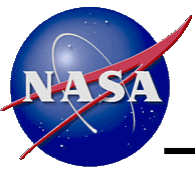






# Concept Realization (15 Months to Field)





# Concurrent Design Lessons

- CAD integration rapidly grew to system simulation, then concurrent development
  - Concepts were matured in design sessions
    - Concept developed, “model” updated, package base lined
    - Design completed, “model” updated, systems built
    - Multiple Centers, Teams, Projects, Time Zones and Budgets
- **Success not just because of Simulation**
  - HDU leadership prioritized decisions such that time critical elements were decided on first
    - Even if only allocations
  - **Simulation Screen Shots became a key communication path**
    - Timely, Enhanced Understanding, Converged Ideas

*Concept*

*Design*

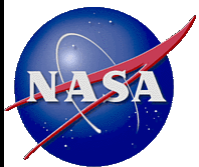
*Development*

*Done*

13

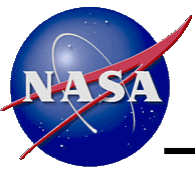






# Self Grading Observation

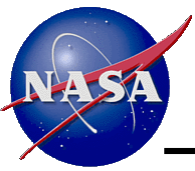
NASA Standard 7009, Modeling and Simulation



# The Numbers on the Score Sheet

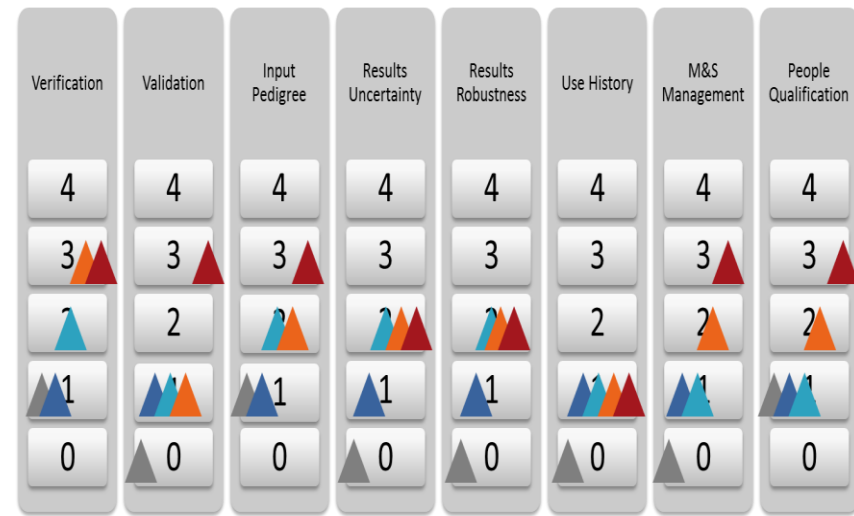
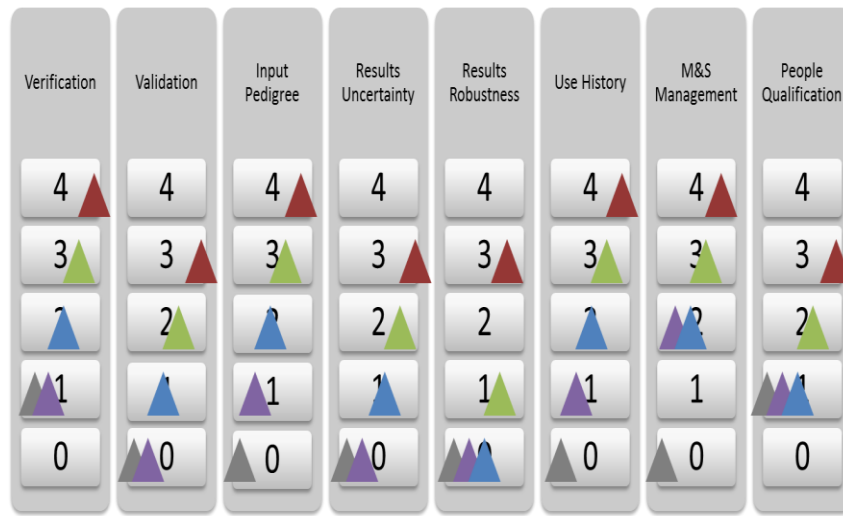
- To communicate the rigor, fidelity and pedigree of our work (Credibility), across distance and years
- We used NASA Standard 7009
  - 8 categories, 5 levels per category
  - Range from “No Evidence” to “Best Possible” Credibility

Inputs Agree with Real World Data			De facto Standard			M&S Management	People Qualification
Verification	Validation	Input Pedigree	Results Uncertainty	Results Robustness	Use History		
4	4	4	4	4	4	4	4
3	3	3	3	3	3	3	3
2	No Evidence of Input Pedigree		2	2	2	2	2
1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0



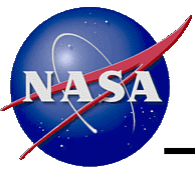
# As Programs Mature, Credibility Increases

- Compare the planned Constellation (crewed) maturation with a flight experiment (no crew)
  - The experiment first pass has higher credibility, but the end result is only 2's and 3's.
  - They do more work up front before commitment, but do not need the later, expensive, high fidelity simulations.



Peer Review  
SRR  
PDR  
CDR  
O/FRR

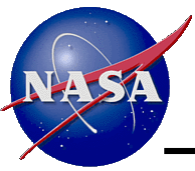
MCR  
SRR  
PDR  
CDR  
O/FRR



# Standard Grades

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- This lets engineers, scientists, analysts and others identify what they created, and what it could be used for.
- It also lets leadership understand what something should NOT be used for.



# Going Forward

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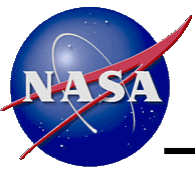
- Just wanting to meet huge new challenges is not enough
  - We must learn how to start meeting them today
    - With our partners, wherever they are
  - We must enable our children to finish tomorrow
    - Simple and persistent mechanisms to communicate with them whenever they are
- We must Learn how to Play Nice Across Space and Time





# **This Might Work Observation**

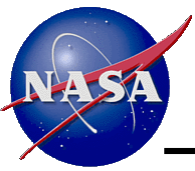
SEE 2015, a template for integrated exploration



# Simulation Exploration Experience

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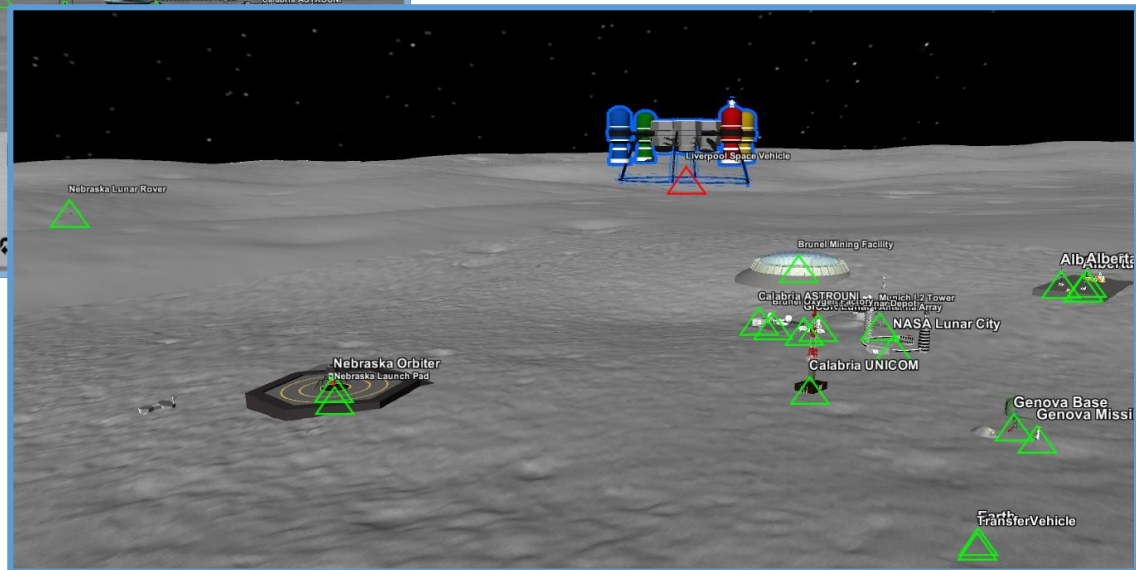
- Cooperative Student Event
  - US, Canada, Europe so far
  - Simulate a Lunar Base with NASA Tools
    - HLA (MAK, Pitch, Forward Sim)
    - Trick (NASA Open Source)
    - Federations (rovers, flyers, surveyors, buildings, terrain)
    - DON, Distributed Observer Network (Game Based Visualizer)
    - Model Process Control data, creates persistent simulations

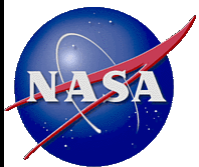


# Data from SEE 2015 Event



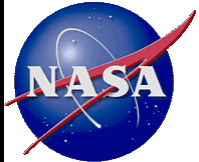
```
<object id="UoL Space Vehicle">  
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0.7726450948750871 -  
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0.14184624855957192</quat>  
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<vis>1</vis></object>
```





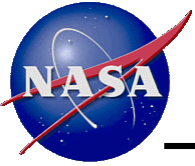
# Questions?

More Observations?



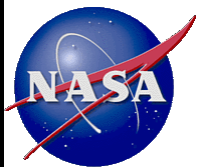
# Backup Stuff





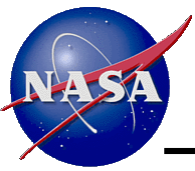
# SEE 7009 CAS Score = 0-1-0-0-0-1-1-1

Verification	Validation	Input Pedigree	Results Uncertainty	Results Robustness	Use History	M&S Management	People Qualification
Reliable error estimates used, small errors across key elements	Results compare favorably to real-world system	Inputs agree with real-world data or from > 3.5 summary M&S	Quantitative and based on Non-deterministic & numerical analysis	Sensitivity known for most parameters (all of the most sensitive cases)	De facto standard	Continual process improvement to improve result repeatability	Extensive experience and use of recommended M&S practices & tool
Formal method is used to assess unit testing errors	Results agree with experimental data for problems of interest	Inputs agree with exp. data for problems of interest or from > 3.0 summary M&S	Quantitative and based on Non-deterministic analysis	Sensitivity known for many parameters	Previous predictions were later validated by mission data	Process measured for repeatability	Adv. degree or extensive experience, recommended practice knowledge
Favorable results from key feature unit / regression testing	Results agree with experimental data or other M&S on unit problems	Inputs traceable to formal doc., or from >2.0 summary M&S	Based on deterministic analysis or expert opinion	Sensitivity known for a few parameters	Used before for critical decisions	Established process for development and operations	Formal M&S training and experience + recommended practice training
Favorable evidence of verification for concept & math models	Concept and math models agree with general and textbook referents	Inputs traceable to informal doc., or from > 1.0 summary M&S	Based on qualitative estimates	Sensitivity estimated, qualitative, based on analogy	Passes simple tests comparing with other similar tools	Roles and Responsibilities defined and managed	Engineering or science degree
No Evidence	No Evidence	No Evidence	No Evidence	No Evidence	No Evidence	No Evidence	No Evidence

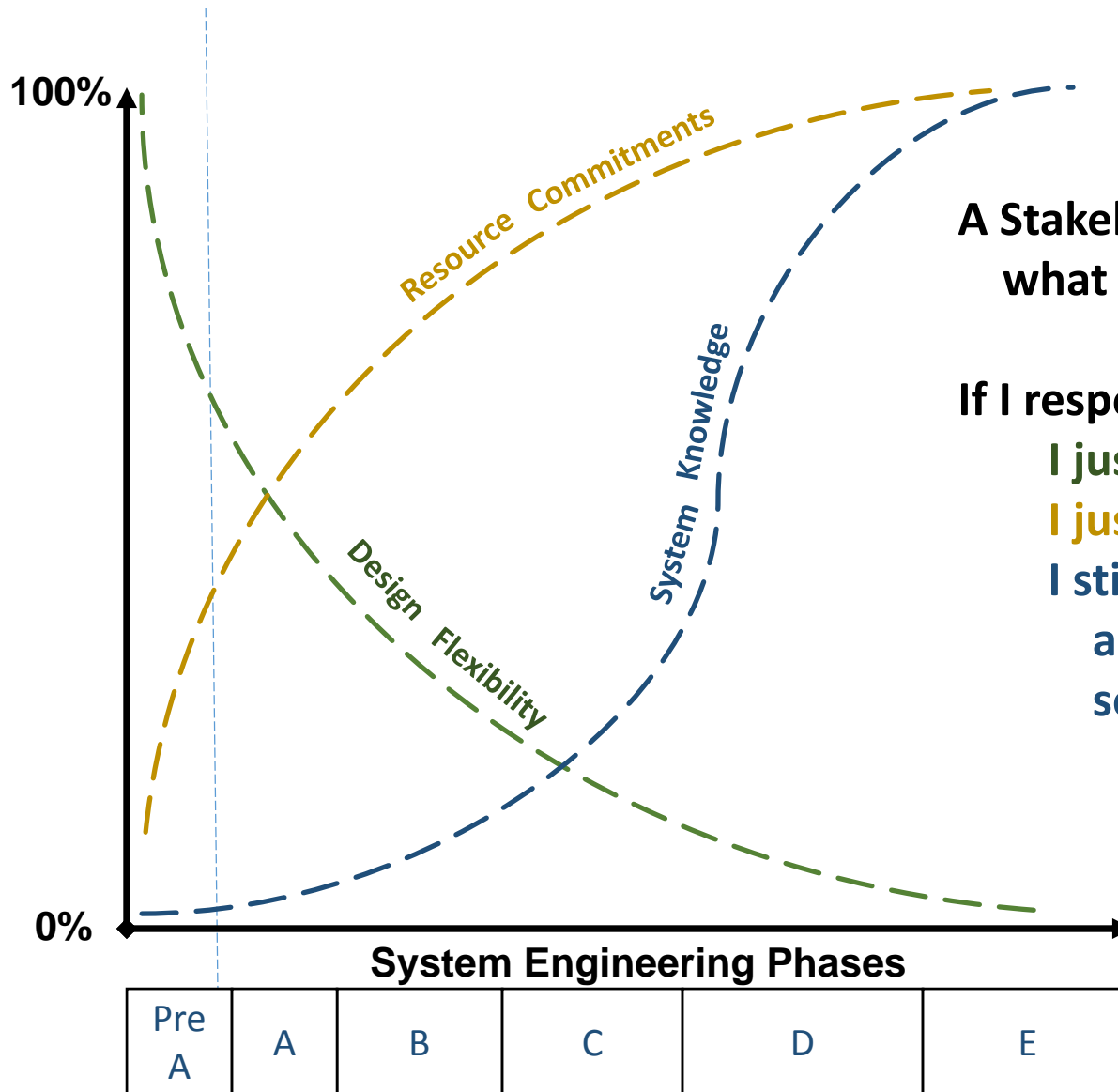


# Design Process Observation

“The” System Engineering Chart



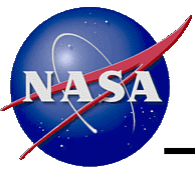
# A Stereotypical Design Process



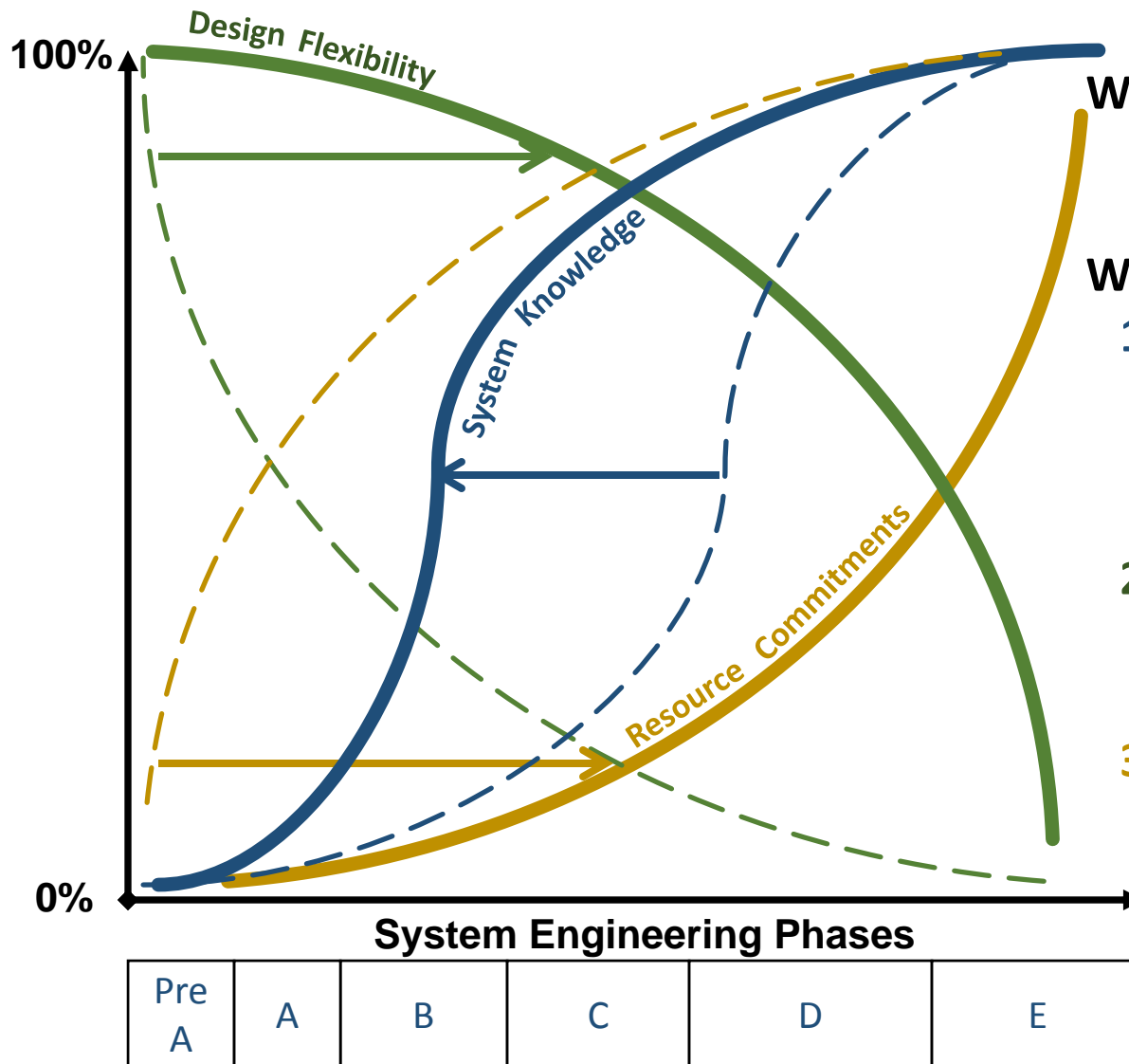
A Stakeholder wants to know what “It” will look like.

If I respond with anything:

- I just lost design flexibility
- I just defined the cost plan
- I still really know very little about the system or solution



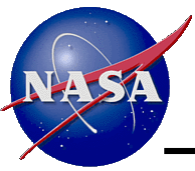
# I Really Want is...



When Stakeholder asks  
“What will it look like?”

What “We” Really Want:

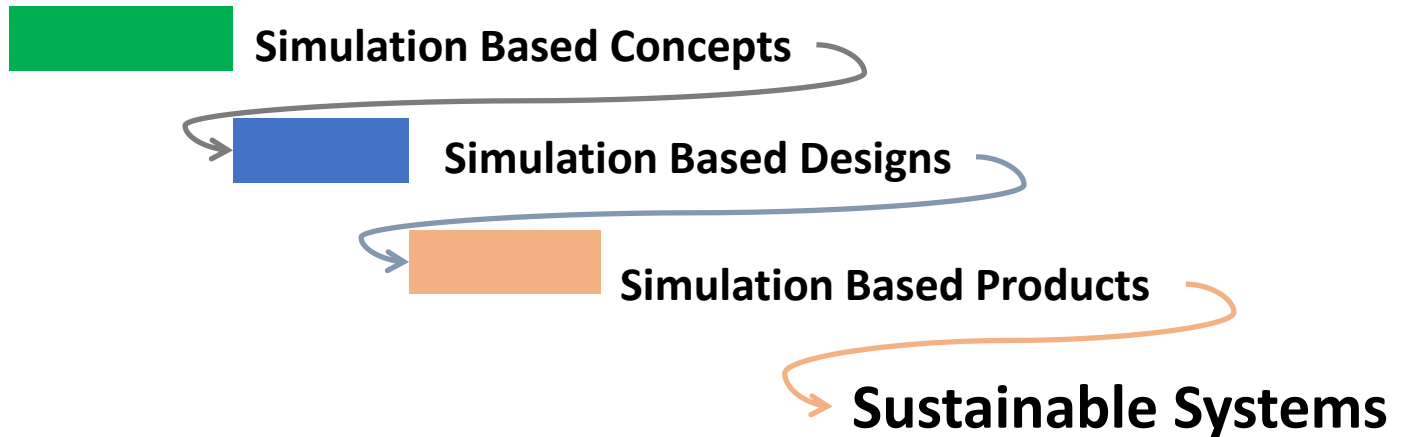
1. I can show you in a few months, not years (Early System Knowledge)
2. Then you can help steer me (Design Flexibility Preserved)
3. And we can look at the financial burn (Delayed Resource Commitments)



# Sustainable Systems

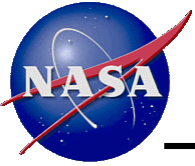
## NASA / INCOSE System Engineering Phases

Pre A	A	B	C	D	E
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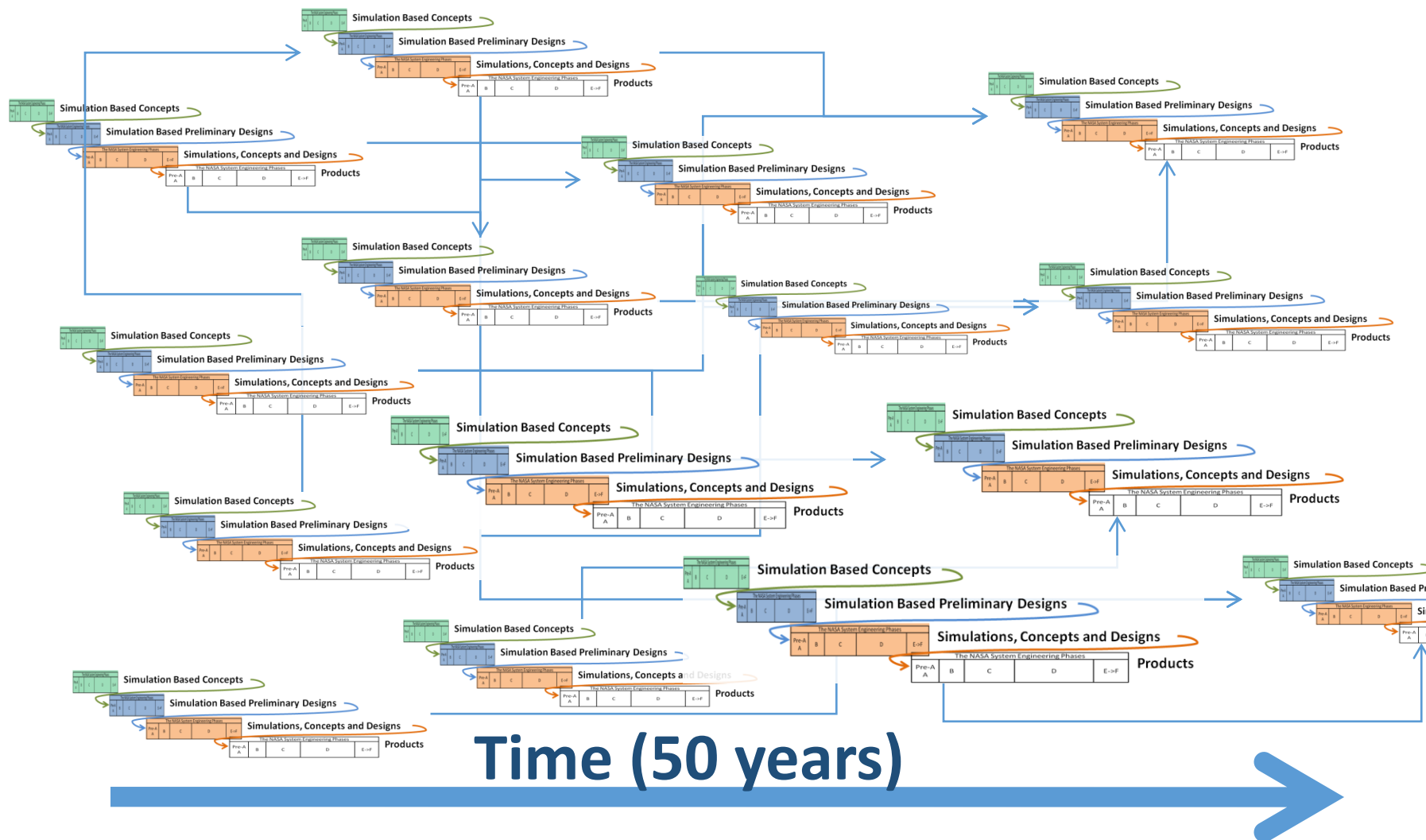
*And, along the way we create artifacts that we can share, that increase understanding and allow us to access additional expertise*





# Multi-Decadal and Interdependent are Hard

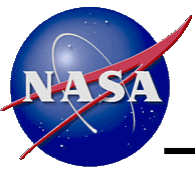
Emerging Disruptive Technologies Assessment Symposium 2015



Us

Our  
Kids

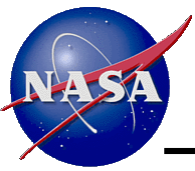
Our  
Grandkids



# Persistent Simulation

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- Persistent Simulation for Multi-Decadal Teams
  - Or, Playing Nice Across Time and Space
- Bio – Mike Conroy / Modeling, Simulation, IT Technology Manager / Kennedy Space Center
  - Experience from Expendable Launch Vehicles, Space Shuttle, a multi-year sentence in financial management, computer networks and data systems, engineering environments, contracts, group management and Modeling and Simulation for the Constellation Program.
  - Now leading Kennedy M&S and IT Research management while building simulators and game based tools for NASA Exploration efforts.



# If I Can Get Simulation in Early I Get

Simulation Based Concepts and Architectures that Lead to...

Simulation Based System Designs that Lead to...

Simulation Based Integration and Operations.

And, that gets us...

